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## Solving Quadratic Equations with the Quadratic Formula: Complex Solutions

For any quadratic equation  $ax^2 + bx + c = 0$ ,  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ .

Complex numbers are written in the form  $a + bi$  where  $i^2 = -1$ ,  $i = \sqrt{-1}$ . Complex numbers include the set of Real and Imaginary numbers.

### I. Model Problems

In the following examples you will solve quadratic equations with the quadratic formula over the set complex numbers.

**Example 1: Solve:  $x^2 - 5x + 10 = 0$ .**

Write down the equation.

Identify the values of  $a$ ,  $b$ , and  $c$ .

Write down Quadratic Formula.

Substitute.

Simplify.

Simplify the radical and reduce.

The solution is:

You can also write the answer as two separate expressions.

$$\begin{aligned}x^2 - 5x + 10 &= 0 \\a = 1 \quad b = -5 \quad c = 10 \\x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\x &= \frac{-(-5) \pm \sqrt{(-5)^2 - 4(1)(10)}}{2(1)} \\x &= \frac{5 \pm \sqrt{25 - 40}}{2} \\x &= \frac{5 \pm \sqrt{-15}}{2} \\x &= \frac{5 \pm i\sqrt{15}}{2} \\x &= \frac{5 \pm i\sqrt{15}}{2} \\x &= \frac{5 - i\sqrt{15}}{2}, \frac{5 + i\sqrt{15}}{2}\end{aligned}$$

**Example 2: Solve:  $-2x^2 + 4x + 6 = 15$ . Write your solutions as an exact answer(s).**

Write down the equation.

Rearrange so the equation is equal to zero.

Identify the values of  $a$ ,  $b$ , and  $c$ .

Write down Quadratic Formula

Substitute.

Simplify.

Simplify the radical and reduce. The solution is:  $\emptyset$

$$\begin{aligned}-2x^2 + 4x + 6 &= 15 \\-2x^2 + 4x - 9 &= 0 \\a = -2 \quad b = 4 \quad c = -9 \\x &= \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \\x &= \frac{-(-4) \pm \sqrt{(-4)^2 - 4(-2)(-9)}}{2(-2)} \\x &= \frac{-4 \pm \sqrt{-56}}{-4} \\x &= \frac{2 \pm i\sqrt{14}}{2}\end{aligned}$$

## II. Practice solving quadratics with the quadratic formula.

1.  $x^2 - 4x - 7 = 0$

2.  $x^2 + 6x + 13 = 0$

3.  $a^2 - 7a - 10 = 0$

4.  $x^2 + 4x + 2 = 0$

5.  $a^2 - 5a + 8 = 0$

6.  $x^2 - 3x + 10 = 0$

7.  $b^2 - 7b - 3 = 0$

8.  $3a^2 - 4a - 4 = 0$

9.  $-c^2 - 6c + 8 = 0$

10.  $2a^2 - 6a - 3 = 0$

11.  $3d^2 - 5d + 6 = 0$

12.  $4x^2 + 11x = 3x - 10$

13.  $14 - 3a^2 = 2a$

14.  $7 - 8z^2 = 6z + 16$

15.  $3x^2 - 11x = 8 - 14x$

16.  $2t^2 + 15 = 6t^2 - 5t$

17.  $10x^2 - 11x + 9 = 13x - 6x^2$

18.  $3t^2 + 8t + 5 = -2t^2$

## III. Challenge Problems

19.  $x^4 + 13x^2 + 36 = 0$

20.  $x^4 + 16x^2 - 225 = 0$

21. The height of a ball in feet can be found by the function  $h(t) = -16t^2 + 80t + 5$  where  $t$  is the elapsed time in seconds. Find the time or times that the ball is 34 feet high to the nearest tenth of a second.

22. The height of a rocket in meters can be found by the function  $h(t) = -4.9t^2 + 540t + 25$  where  $t$  is the elapsed time in seconds. Find the time or times that the rocket is 750 meters high to the nearest tenth of a second.

23. What value(s) of the discriminant result in one unique real solution?

24. What value(s) of the discriminant result in two unique imaginary solutions?

#### IV. Answer Key

1.  $x = 2 \pm \sqrt{11}$

2.  $x = -3 \pm 2i$

3.  $a = \frac{7 \pm \sqrt{89}}{2}$

4.  $x = -2 \pm \sqrt{2}$

5.  $a = \frac{5 \pm i\sqrt{7}}{2}$

6.  $x = \frac{3 \pm i\sqrt{31}}{2}$

7.  $b = \frac{7 \pm \sqrt{61}}{2}$

8.  $a = 3$  or  $-\frac{2}{3}$

9.  $d = \frac{-5 \pm 4\sqrt{6}}{6}$

10.  $a = \frac{3 \pm \sqrt{15}}{2}$

11.  $d = \frac{5 \pm i\sqrt{47}}{6}$

12.  $x = \frac{-2 \pm i\sqrt{6}}{2}$

13.  $a = \frac{1 \pm \sqrt{43}}{3}$

14.  $z = \frac{-3 \pm 3\sqrt{7}}{8}$

15.  $x = \frac{-3 \pm \sqrt{105}}{6}$

16.  $t = \frac{5 \pm \sqrt{265}}{8}$

17.  $x = \frac{3}{4}$

18.  $t = \frac{-4 \pm 3i}{5}$

19.  $x = \pm 3i, \pm 2i$

20.  $x = \pm 3, \pm 5i$

21. 0.39 sec and 4.61 sec

22. 1.36 sec and 108.84 sec

23. The discriminant is positive.

24. The discriminant is zero.

25. The discriminant is negative.